THE GPS TOPEX/POSEIDON PRECISE ORBIT DETERMINATION EXPERIMENT: IMPLICATIONS FOR DESIGN OF GPS GLOBAL NETWORKS

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Topex/Poseidon, an element of the World Climate Research program, is a cooperative space program between the United States and France which will provide the measurement capability needed to determine global circulation patterns of the oceans and study their influence on world climate. An altimeter precise to about 2 cm is used to determine the sea surface height above the geoid. Altitude orbit error is a major error source for interpretation of the altimeter measurements. Based on the science aims of the mission, the goal was to achieve better" than 13-cm accuracy for the altitude of the orbit.

The Topex/Poseidon mission includes an experimental Global Positioning System (GPS) precision orbit determination (POD) system that has now demonstrated a sub-10-cm accuracy in altitude determination. The GPS POD system features a GPS flight receiver and global GPS tracking from 6 ground stations which are operated by NASA and co-operating international agencies. This paper will review early results from the GPS flight experiment, and discuss the performance, siting, and operating characteristics of the 6-station GPS global network. The paper will then discuss the multi-mission capabilities available from a future enhanced global GPS tracking network as a function of its characteristics. In the future, the enhanced GPS global network can provide ground-based geophysical and atmospheric measurements needed for NASA deep space missions while also supplying tracking data for low Earth orbiters, similar to Topex/Poseidon.

In addition to meeting the requirements for low Earth orbiter tracking, a global GPS network will be able to provide Earth platform, clock, and media calibrations needed to support NASA's deep space interplanetary missions. For deep space tracking, the media and Earth platform errors often limit the navigation accuracy and the science returns. The use of GPS for calibration will save operating costs and reduces the amount time that 70-m antennas devote to calibration activities. 70-m antenna time is in high demand and is expensive, so the use of the global GPS data is expected to have a positive impact on Deep Space Network (DSN) operations.

Future low Earth orbiter missions will have significantly more challenging goals than Topex/Poseidon in terms of accuracy, turnaround time, and mean time to repair hardware failures. We will show that a relatively small (12 site) operational global GPS tracking network will meet the future requirements for both low earth orbiters and DSN calibration. Fast repair times ensure all 12 sites can be relied upon for nearly continuous operation and that uniform data sets will be obtained. Automated processing makes GPS inexpensive compared to other tracking technologies. Rapid data turnaround permits quick detection and repair of hardware problems and also enables support for very low Earth orbiters which may require maneuvers to avoid altitude loss from drag.

The 12-station global GPS network is expected to provide continuing tracking support for low Earth orbiters such as STEP, Gravity Probe-B, Topex/Poseidon follow-on and EOS ALT missions. Additional altimetric satellites will lead to better understanding of the ocean circulation, providing information about the interaction between ocean and weather patterns. Benefits include improved forecasting of weather patterns important to agriculture, the energy industry, and society as a whole. Altimetric missions could also help efforts to predict phenomena that greatly affect world economics, such as the El Nino effect, a warming of eastern Pacific waters that is associated with weather changes causing billions of dollars of damage in addition to the loss of fishing industries of a number of nations. Better knowledge of ocean circulation may also help scientists better understand the process by which carbon dioxide in the atmosphere is absorbed by the oceans — an important component of the thermal balance of the planet and possibly one component related to global warming. The benefit to mankind of this research could be enormous.